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Applicants : Hamid Hojaji et al.

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DECLARATION UNDER 37 C.F.R. § 1.132

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, PEDRO M. BUARQUE DE MACEDO, declare that:

1. I am the co-inventor and assignee of the above-referenced U.S. Patent Application Serial No. 10/625,071 filed on July 22, 2003 in the name of Hamid Hojaji and Pedro M. Buarque de Macedo and entitled "STRONG, HIGH DENSITY FOAM GLASS TILE HAVING A SMALL PORE SIZE."

2. I am familiar with the above-referenced patent application and the prosecution thereof before the U.S. Patent Office. I am also familiar with the Office Action dated November 24, 2006 issued therein. For the purposes of preparing this Declaration, I have reviewed the prior art references cited in the Office Action, including U.S. Patent No. 5,588,977 to Pavlov et al. ("the Pavlov '977 Patent"), U.S. Patent No.

5,821,184 to Haines et al. ("the Haines '184 Patent") and U.S. Patent No. 5,069,960 to Fukumoto et al. ("the Fukumoto '960 Patent"). Based on my extensive academic and research experience as described below I am generally familiar with the field related to the above-mentioned prior art references and I believe that I am qualified as an expert in that field.

3. I received a Bachelor of Science degree in Physics from George Washington University in Washington D.C. in 1959, and received a Ph.D. in physics from The Catholic University in 1963. From 1963 to 1967, I was employed with the National Bureau of Standards, and afterwards I continue to be associated with the National Bureau of Standards as a consultant. In 1967, I joined the department of mechanics at The Catholic University of America as an associate professor. In 1970, I became a co-director of the Vitreous State Laboratory and also a professor of chemical engineering and material science at the same university. Currently, I continue to be the director of the Vitreous State Laboratory and am a professor of physics at the same university. The article in the Summer 2002 issue of the *CUA Magazine*, "Defending Against Environmental Disaster: CUA's Vitreous State Lab Has Answered the Nation's Call for 30 Years" by Richard Wilkinson, a copy of which is attached hereto as Exhibit 1, describes my contributions and achievements as a co-director of the Vitreous State Laboratory.

4. My primary area of expertise is in glass science research. In particular, I have developed technologies and products in the areas of fiber optics, defense fuels, and radioactive waste glass formulation. I have received over 40 patents in the United States and many more worldwide, and have been noted as "the area's leading individual

inventor in number of patents granted" by the January/February 1990 issue of *Washington Business Journal Magazine*. For more details of my background and areas of expertise, please refer to my curriculum vita attached hereto as Exhibit 2.

5. I have reviewed the Pavlov '977 Patent, and do not find therein any teaching or even suggestion of a foam glass tile having, *inter alia*, a compression strength of 10,000 psi or greater, as required by Claim 90, let alone the claimed range of 12,500 psi or greater for Claim 63. At best, the Pavlov '997 Patent discloses in Example 22 a foam glass product having a compression strength of 8,700 psi (converted from 60MPa), which falls short of the claimed range of 10,000 psi or greater for Claim 63, let alone the claimed range of 12,500 psi or greater required by Claim 90. *See* Pavlov '997 Patent, Example 22, Col. 11, lines 45-55. All other examples of the Pavlov '997 Patent disclose foam glass products having a compression strength less than 8,700 psi.

6. Furthermore, the Pavlov '977 Patent discloses that the pore sizes of its foam glass material can range to "several millimeters." Pavlov '977 Patent, Col. 6, lines 13-14. As further explained in Paragraph 7 below, in the course of making strong foam glass tiles as disclosed and claimed in the present application, we have found that the size of the largest pore or bubble within a foam glass material can be one of the necessary factors in determining its compression strength. In general, we found the presence of large bubbles weaken the foam glass material and indicate a low compression strength.

7. To make a strong foam glass tile as described in the present application, we made many examples of various compression strength, and from these examples, we

have found the following necessary properties of the strong foam glass tiles that are made in accordance with the present invention: (a) The higher the density of the finished foam glass tile, the stronger the foam glass tile. This property would be counter-intuitive to the conventional wisdom for desiring light foam glass tiles since a higher density means a heavier weight; and (b) foam glass tiles having small pore sizes are generally stronger than foam glass tiles having larger pore sizes. More specifically, the pore size is determined by the largest dimension of the pore, and the compression strength of a foam glass tiles was seen impacted by the largest pores. However, these are necessary but not sufficient conditions for the strong foam glass tiles. In fact, our recent efforts to replicate the foam glass article in accordance with the teachings of the Haines '184 Patent, as discussed in Paragraph 12 below, show that not all foam glass tiles having the average pore size and density within the claimed ranges required by the pending claims can achieve the claimed compression strength. Thus, while the claimed ranges of average pore size and density are necessary properties of a strong foam glass tile in accordance with the present invention, they are not sufficient by themselves to lead to the claimed compression strength. The procedures disclosed in the present application teach a method by which a foam glass tile with the appropriate pore size and density and compression strength, as claimed, can be made.

8. By way of comparison, the color photographs in FIGS. 1-3 below this paragraph show the cross sectional views of the foam glass tile samples made in accordance with the present invention. In fact, FIGS. 1-3 correspond respectively to Examples 7-9 in TABLE 3 of the present application. Once the corresponding samples

were made, they were cut to take the measurements of various properties, revealing the cross sectional views shown in FIGS. 1-3. FIG. 1 corresponds to a foam glass tile of Example 7 having an average pore size of 0.8 mm. As can be seen from FIG. 1, none of the largest pore sizes is over 1.0 mm. The measured compression strength of Example 7 is 10,500 psi. Similarly, Example 8 shown in FIG. 2 has an average pore size of 0.6 mm, with, again, none of the largest pore sizes over 1.0 mm. It achieves a compression strength of 12,500 psi. Example 9 shown in FIG. 3 has an average pore size of 0.3 mm, with none of the largest pore sizes over 1.0 mm, and achieves a compression strength of 14,600 psi.

FIG. 1: Example 7 of Present Invention in TABLE 3

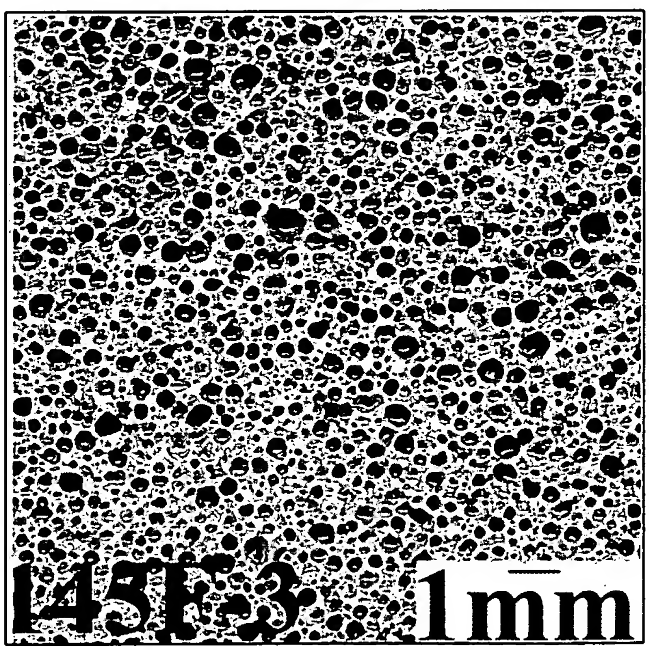


FIG. 2: Example 8 of Present Invention in TABLE 3

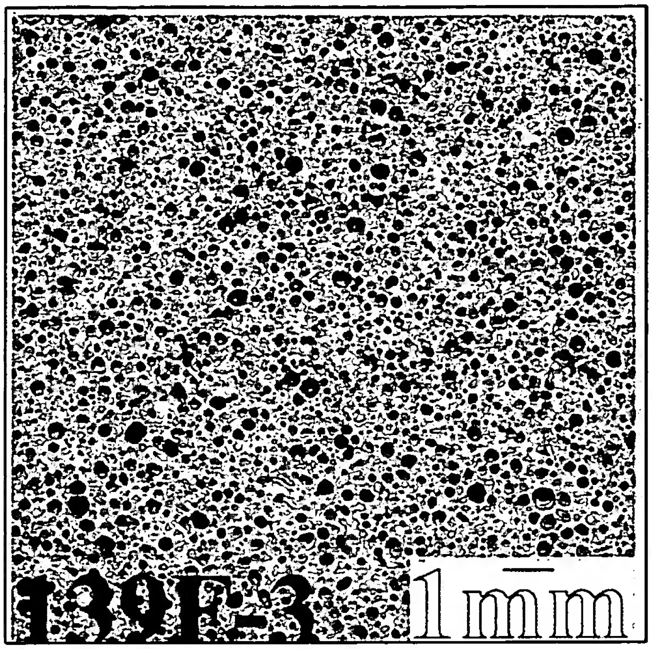
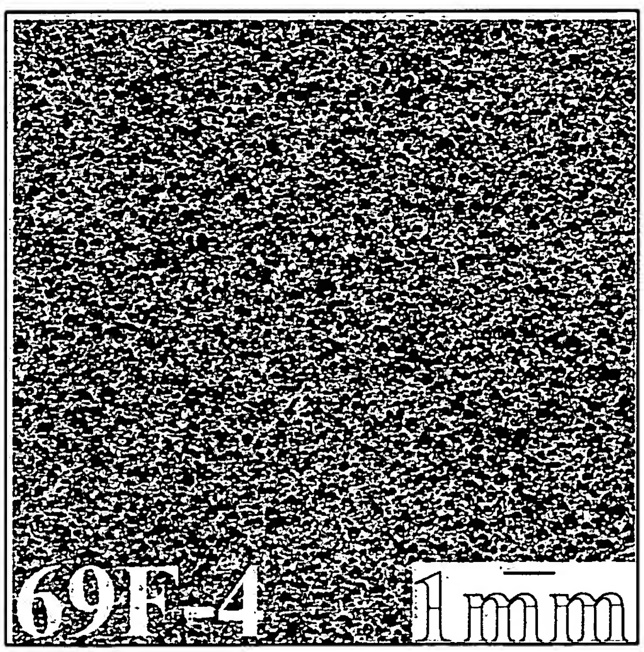


FIG. 3: Example 9 of Present Invention in TABLE 3



9. Based on my foregoing observations that small pore sizes with the largest of them being smaller than 1.0 mm are necessary (but not sufficient by themselves) condition for a high compression strength in a foam glass tile, as well as my general knowledge that the presence of large pores or bubbles tend to weaken a foam glass material, I conclude that a foam glass material having largest pores reaching several millimeters in size would unlikely achieve the claimed range of 10,000 psi or greater in compression strength as required by Claim 90, let alone the claimed range of 12,500 psi or greater required by Claim 63. This further confirms my earlier observation that the Pavlov '977 Patent does not disclose the claimed ranges of compression strength.

10. I have also reviewed the Haines '184 Patent, and do not find any teaching or suggestions therein of a foam glass tile having, *inter alia*, a compression strength within the claimed range of 10,000 psi or greater as required by Claim 90, let alone the claimed range of 12,500 psi or greater for Claim 63. In fact, I do not find any compression strength data for the 18 examples of foam glass articles in the Haines '184 Patent.

11. Of the 18 examples of foam glass articles disclosed by the Haines '184 Patent, none has a density within the claimed range of 50 pcf or greater as required by independent Claim 90. Furthermore, of the 18 examples, Example 17 is the only example having a density (42.6 pcf) and an average pore size (ranging between 0.01 and 0.10 mm) that are both within the claimed ranges required by independent Claim 63. *See* Haines '184 Patent, Example 17, Col. 9, line 62. However, the Haines '184 Patent provides no compression strength data for any of the examples, including Example 17.

The properties of the 18 examples of the Haines '184 Patent are summarized in a table below:

REFERENCE: HAINES USP# 5,821,184 '184									
EXAMPLE	DENSITY (pcf)	IN/OUT	PORE SIZE (mm)	IN/OUT	TILE SIZE (in)	VOLUME (in)	VOLUME (ft)	MASS (lbs)	IN/OUT (10# -IN)
1	13.9	OUT	0.5 - 2.0	OUT	4x4x4	64	0.0370	0.5148	OUT
2	7.2	OUT	1.0 - 3.0	OUT	NO SIZE GIVEN				?
3	17.6	OUT	0.05 - 0.2	IN	2x3x4	24	0.0139	0.2444	OUT
4	15.3	OUT	0.01 - 0.1	IN	NO SIZE GIVEN				?
5	24.3	OUT	0.1 - 0.5	IN	3x2x8	48	0.0278	0.6750	OUT
6	19.8	OUT	0.05 - 0.2	IN	NO SIZE GIVEN				OUT
7	11.2	OUT	0.5 - 1.5	OUT	4x3.75x2	30	0.0174	0.1944	OUT
8	15.6	OUT	0.5 - 1.0	IN	NO SIZE GIVEN				?
9	27.8	OUT	1.0 - 3.0	OUT	NO SIZE GIVEN				?
10	17.2	OUT	2.0 - 4.0	OUT	NO SIZE GIVEN				?
11	19.5	OUT	1.0 - 2.4	OUT	6d, 2t	56.52	0.0327	0.6378	OUT
12	14.8	OUT	0.5 - 1.5	OUT	5d, 2t	39.25	0.0227	0.3362	OUT
13	11.9	OUT	1.2 - 2.8	OUT	2x3.75x7.25	54.375	0.0315	0.3745	OUT
14	18.3	OUT	2.0 - 4.0	OUT	NO SIZE GIVEN				?
15	16.6	OUT	0.05 - 0.2	IN	4x4x8	128	0.0741	1.2296	OUT
16	28.6	OUT	0.01 - 0.2	IN	4x4x3	48	0.0278	0.7944	OUT
17	**42.6**	**IN**	**0.01 - 0.1**	**IN**	**NO SIZE GIVEN**				**?**
18	19.3	OUT	0.2 - 0.5	OUT	1x2x20	40	0.0231	0.4468	OUT

12. Under my direction and supervision, an experiment was conducted in my university laboratory to replicate the foam glass article described in Example 17 of the Haines '184 Patent. *See* Haines '184 Patent, Col. 9, lines 57-63. Example 17 indicates that a procedure similar to that of Example 1 is used. All of the steps and recipes for producing a foam glass block as prescribed by Examples 1 and 17 of the Haines '184 Patent were faithfully followed in the experiment to every extent possible. These steps and recipes are summarized in the table below:

	EXAMPLE 1			EXAMPLE 17			
CHEMICAL	WT (g)	%	MESH	WT (g)	%	MESH	
CALCIUM CARBONATE, $CaCO_3$	13.68	2.4	>200	114	20	>325	
RECYCLED **PLATE GLASS**	442.32	77.6	>140	456	80	>325	RECYCLED **CONTAINER GLASS**
SAND	114	20	60_100				
TOTAL	570	100		570	100		

PROCESS STEPS TO REPLICATE EXAMPLE 17 (AS ABOVE)
1 Mix powders thoroughly
2 Place resulting mixture in a stainless steel mold, approx. 4.25"x4"x8.25"
3 Cover mold with a 0.5" stainless steel plate
4 Fire the mold with the mixture therein at 1250 °F (677°C) to sinter for 60 minutes
5 Foam for 15 minutes at 1700 °F (927°C)
6 Anneal by cooling slowly to room temperature for 120 minutes
7 Remove the cooled block of foam glass from the mold
8 Remove the outer layer of crust with a saw
9 Measure the density, pore size distribution and compressional strength of the finished product.
10 Check if cells are interconnected

13. I found that the foam glass article produced in the above experiment matches the density and pore size distribution disclosed in Example 17 of the Haines '184 Patent, confirming that the experiment properly followed the teachings set forth in the Haines '184 Patent. A series of color photographs below this paragraph, FIGS. 4-8, show the foam glass article produced in accordance with the teachings set forth in Example 17 of the Haines '184 Patent in the above experiment that were taken from various angles.

FIG. 4: Replication of Example 17 of Haines '184 Patent Seen From the Top

FIG. 5: Replication of Example 17 of Haines '184 Patent Seen From A Side

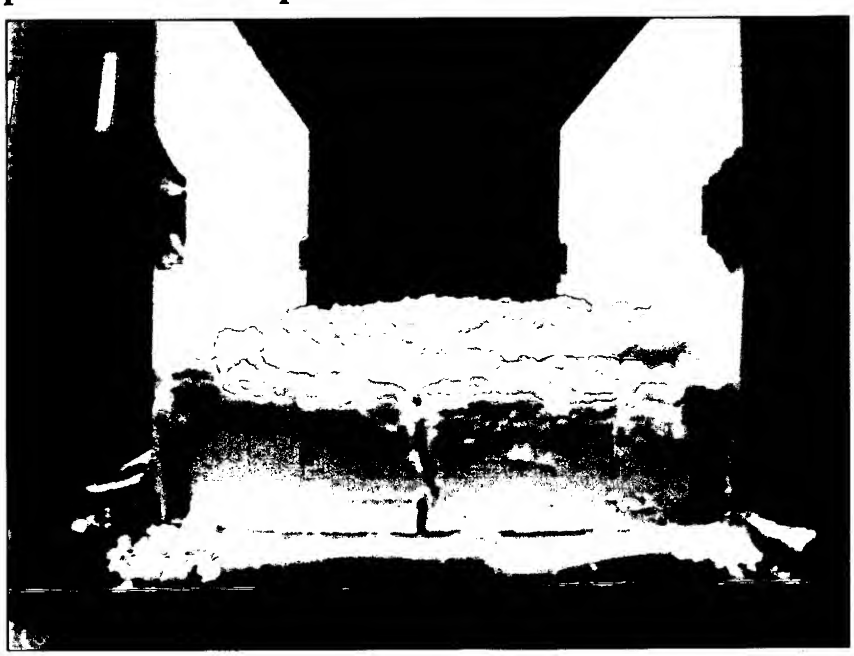


FIG. 6: Replication of Example 17 of Haines '184 Patent Seen From Another View

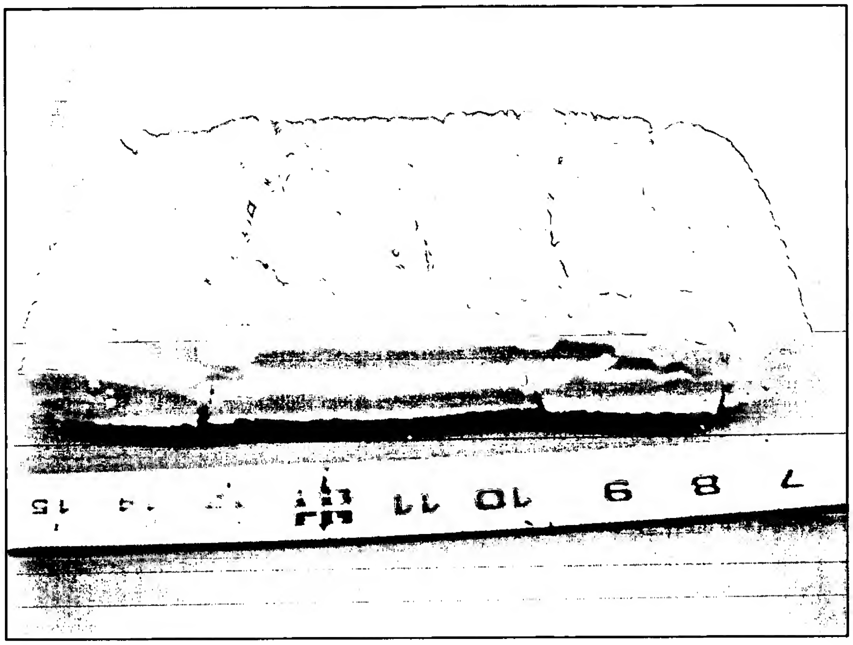


FIG. 7: Replication of Example 17 of Haines '184 Patent Seen From Another View

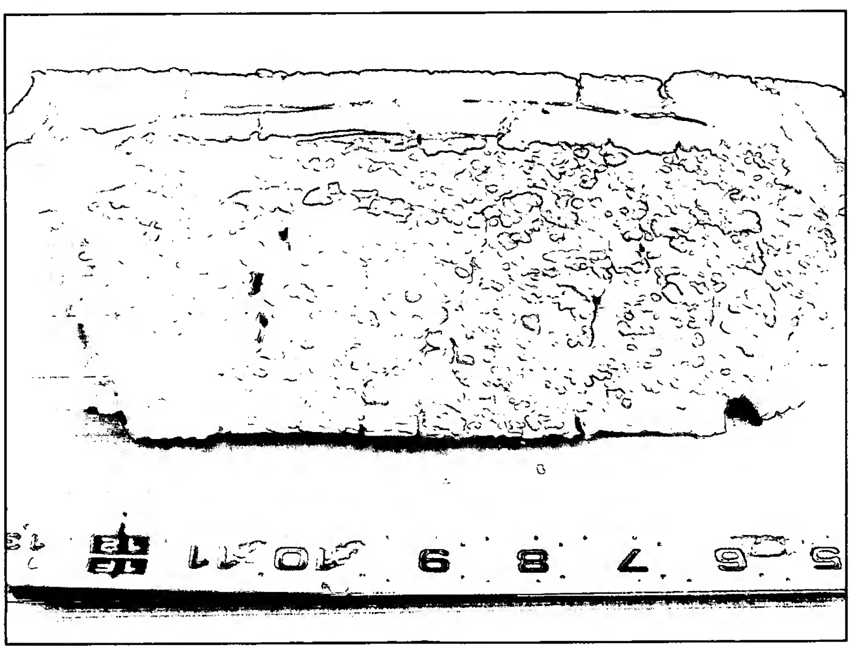


FIG. 8: Replication of Example 17 of Haines '184 Patent Seen Closely at the Pore Size Level (Marks on the Bottom Indicating a Millimeter)

14. The above figures, FIGS. 4-8, clearly show that the foam glass article produced in accordance with Example 17 of the Haines '184 Patent developed large cracks and severe fractures running across the surfaces and through the body.

15. I also observed that while the pores or bubbles in the foam glass article produced in accordance with Example 17 of the Haines '184 Patent have the sizes disclosed by the Haines '184 Patent, i.e., ranging from about 0.01 to 0.1 mm, they are in fact mostly interconnected, with the resulting interconnected bubble structure reaching several millimeters in length. This can be seen from a close-up view of the fluffy sample shown in FIG. 8, although the photo does not have a very clear contrast against the white sample. My observation is confirmed by the Haines '184 Patent which discloses

that "the cell structure of the inventive foam glass is open, interconnected, and irregular." Haines '184 Patent, Col. 4, lines 61-62.

16. Based on the foregoing observations, I conclude that the foam glass article produced in accordance with Example 17 of the Haines '184 Patent containing large cracks and fractures, as well as long interconnected bubbles, running across the surface and through the body do not meet the necessary condition to achieve a high enough compression strength suitable for the intended purpose and use contemplated by the present invention, which include use for protective building surfaces and shock absorption.

17. I was not able to obtain any compression strength measurement from the foam glass article produced in accordance with Example 17 of the Haines '184 Patent, since it was too badly cracked. However, even without taking any measurement, based on its clearly observable fragile condition as shown in FIGS. 4-8, I conclude that it does not meet the necessary condition to possess a high compression strength even at the level of 4,000 psi, which is a typical compression strength of a concrete, let alone the claimed ranges of 10,000 psi and greater as required by Claim 90, or 12,500 psi and greater as required by Claim 63.

18. By way of comparison, the photographs of the cross sectional views of foam glass tile samples that are made in accordance with the present invention as shown in FIGS. 1-3 above, having the respective average pore sizes, densities and compression strengths (as described respectively for Examples 7-9 in TABLE 3 of the present application) within the claimed ranges set forth in the pending claims show no cracks or

interconnected pores. The difference between the claimed invention and the foam glass article produced in accordance with the teachings of the Haines '184 Patent could not be more apparent.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: March 26, 2006

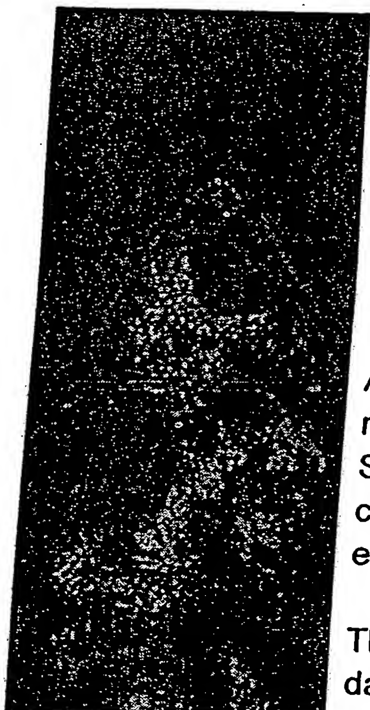
By: Pedro M Buarque de Macedo
Pedro M. Buarque de Macedo, Ph.D.

Defending Against Environmental Disaster

By Richard Wilkinson

CUA's Vitreous State Lab Has Answered the Nation's Call for 30 Years

Sidebar: **A New Direction**



Above: Nuclear waste after being melted into glass.

More than a million gallons of high-level radioactive waste have already leaked out of the rusting tanks buried in the desert hills of eastern Washington state — waste that is now percolating slowly toward the Columbia River seven miles away and the city of Portland, Ore., 200 miles downstream.

Another 53 million gallons of deadly radioactive sludge is still contained at the Hanford Site near Richland, Wash., where the plutonium used in America's atomic weapons arsenal was manufactured from 1943 to 1988. Former U.S. Secretary of the Interior Stewart Udall has called containment of this waste "the most urgent environmental emergency" in the United States.

The nuclear waste in question will remain dangerous for thousands of years, and has the potential to wreak a devastating effect on the economy, health and ecology of the Pacific Northwest. The computer visualization on Page 12 shows the underground plumes of waste that have leaked below many of the deteriorating tanks.

Although better known for theology courses and medieval studies, Catholic University is the

research site that perfected the ingenious solution the U.S. Department of Energy is turning to in this potential crisis. The university's low-profile Vitreous State Laboratory, or VSL, which is located in Hannan Hall, will provide scientific oversight to the nuclear waste cleanup for many years to come.

In fact, it appears that CUA's unique expertise will contribute to making the cleanup 20 years faster and up to $20 billion cheaper, says Harry Boston, manager of the U.S. Department of Energy's Office of River Protection, which is leading the waste tank cleanup at the Hanford Site.

The solution the United States has adopted is vitrifying the nuclear waste — turning it into glass in a 2,000-degree Fahrenheit melter patented by the Catholic University laboratory. In general, about 30 to 40 percent of the final glass product is vitrified nuclear waste; the rest is composed of glass-forming substances such as silica or boron.

High-level nuclear waste remains dangerously radioactive no matter what you do with it. But after undergoing vitrification or "glassification," it becomes a durable glass and can't leach into ground water to spread its radioactivity to plants, animals and people. The glass does remain radioactive for thousands of years, however, and much of it will eventually have to be deposited within the bowels of Nevada's Yucca Mountain (or some other long-term federal depository).

Working on something that has to last at least 10,000 years "seems more like religion than science — when you realize that the oldest parts of the Bible were written only 4,000 or 5,000 years ago," says CUA Professor Pedro "Pete" Macedo, Ph.D. 1963, co-founder and co-director of the

Vitreous State Laboratory.

Uniquely Positioned to Serve

One of the leading universities in the world in glass science, CUA has beaten out huge government labs and corporations in competition for federal contracts to vitrify waste at nuclear sites around the country.

CUA's Vitreous State Laboratory provided the scientific oversight for converting radioactive waste into a million pounds of glass at West Valley, N.Y., from 1985 to 1993 — still the largest vitrification of high-level waste ever completed in the United States. The project cost the government $1.6 billion, of which VSL received about $4 million.

Other contracts followed. For instance, from 1994 to 1999, the lab played a major role in the vitrification of 660,000 gallons of low-level radioactive waste and hazardous waste in the Savannah River Reservation, an atomic bomb manufacturing site in South Carolina. VSL technology was incorporated into the world's largest radioactive waste melter there. The CUA lab also analyzed the waste, determined how to make it into glass, and tested the finished products to ensure that they met Environ-mental Protection Agency and Nuclear Regulatory Commission standards.

But the Hanford cleanup is 10 times bigger than those earlier jobs. Enough nuclear waste to fill 2,500 railroad tanker cars roils like a guilty conscience within the Hanford Site's 177 underground tanks. Individual tanks — said to be as big as the dome of the U.S. Capitol Building — hold a million gallons of radioactive liquid and sludge.

Six electrically powered melters are scheduled to be built at Hanford by 2007 and to finish the vitrification by 2046. The facilities will cost $4 billion, and the entire vitrification job is budgeted to cost $50 billion — one of the larger capital projects the federal government is currently undertaking.

However, the Department of Energy now thinks it can reduce those projections by $20 billion and 20 years — "and the work of VSL is absolutely central to that acceleration," says Mr. Boston, who is overseeing the waste-tank cleanup.

"VSL gives us the ability to safely and reliably treat the waste faster than anticipated," he says. One of the reasons is that the CUA lab has come up with significant improvements in the giant melters that turn waste into glass. For example, Professor Macedo and Professor Robert Mohr, VSL's manager of engineering, have increased the amount of waste that can be melted each day by a factor of five, which greatly decreases the cost and increases the speed of vitrification.

"The reason that this vital cleanup project hasn't been started before now," says Mr. Boston, "is that we haven't had the capability and confidence that we could safely and effectively deal with the radioactive waste. That's where VSL comes in."

The Hanford cleanup is an epochal project — "maybe as big a challenge as the Manhattan Project" that created the atomic bomb and produced the first nuclear waste at Hanford, says John D. Wagoner, manager of the Department of Energy's Richland, Wash., office.
Sen. Frank H. Murkowski of Alaska describes the cleanup as "the largest civil works project in the history of mankind," and CUA is in the thick of it.

This isn't the first time VSL has served the nation by developing revolutionary technologies, however. The CUA laboratory has played a major role in the development of fiberoptics, which now forms the backbone of world telecommunications; of the missiles that were used in the war on terrorism in Afghanistan; and of infrared-transmitting glass that lets U.S. reconnaissance planes take pictures of enemy ground soldiers, even at night and under thick foliage.

A Little-Known Force in Science

Much of the world thinks of Catholic University as a place that does theology and philosophy but not physics, says Professor Charles "Chick" Montrose, Ph.D. 1967, chair of CUA's physics department and a co-founder of VSL along with Professor Macedo and Professor Emeritus Theodore Litovitz, B.A. 1946, Ph.D. 1950.

But in addition to housing leading institutes in astrophysics and nuclear physics, CUA boasts some of the nation's leading glass scientists — including Professor Macedo and Associate Professor Ian Pegg, VSL's associate director. Professor Pegg "is the nation's leading expert on vitrification of nuclear waste," says Bradley Bowan, vice president of research at Duratek Inc., a successful nuclear waste management company spawned by VSL in the late 1970s.

CUA's physics department is relatively small, with only nine full-time professors, but along with VSL, it brings in more research money per professor than any other physics department in the nation except for Cal Tech and Berkeley, according to 1999 American Institute of Physics data.

This year, VSL will take in a remarkable $14

million, which amounts to 59 percent of the $23.6 million in research money the university expects to raise.

Until it moved away from a monetary criterion a few years ago, the Carnegie Foundation for the Advancement of Teaching defined a research university as one that brings in at least $15 million in research funding annually. VSL — a small part of Catholic University — is almost that successful in its own right.

Mr. Boston of the Department of Energy says he foresees a long-term role for VSL in the Hanford cleanup. The CUA laboratory has the potential to earn hundreds of millions of dollars from the project over the next 30 years, according to VSL's 2002 annual report.
Nevertheless, VSL keeps a low profile, sometimes creating an aura of mystery at Catholic University. "I teach a physics course for non-science majors," says Professor Montrose, "and the students sometimes ask me, 'Is it true there is a nuclear reactor in the basement of Hannan Hall?' "

In fact, there is no reactor there and very little radioactivity. Only a $4 million, 30-ton melter which is frequently fired up to 2,000 degrees to make glass out of nonradioactive versions of the chemicals found in Hanford waste tanks.

The melters that soon will be built at Hanford — although based on the one in Hannan Hall — will not weigh 30 tons, but 350 tons each.

Birth of a Powerhouse Lab

The story of the Vitreous State Laboratory properly begins in 1936, when Austrian physicist Karl F. Herzfeld left a professorship at Johns Hopkins University to chair Catholic University's then-tiny

physics department. An acquaintance of Albert Einstein, Professor Herzfeld built CUA's "small teaching-oriented department into a strong research department that achieved national renown," writes Joseph F. Mulligan, in the journal Biographical Memoirs, published by the National Academy of Sciences.

While at CUA, Professor Herzfeld brought aboard other world-class physics professors such as Clyde Cowan, co-discoverer of the subatomic particle called the neutrino — a discovery for which Professor Cowan would have shared a 1995 Nobel Prize had he not died before then.

A Jewish convert to Catholicism (as were his parents), Professor Herzfeld saw his calling in terms of his faith. "Physics for Herzfeld was not a secular, but a religious calling; it aimed, in his view, to make clear the structure and beauty of God's creation," writes J.A. Wheeler in his 1979 obituary for Professor Herzfeld in the journal Physics Today.

At CUA, Professor Herzfeld pursued a research interest in the structural and dynamic properties of liquids. That interest in liquid-state physics led his protégé, Professor Theodore Litovitz, and the latter's own protégés, professors Macedo and Montrose, to study glass — which is actually a form of supercooled liquid. In 1967 their growing understanding of glass led professors Litovitz, Macedo and Montrose to ask the U.S. Department of Defense for $600,000 — a huge amount in those days — to fund a Catholic University research center in glass-state (vitreous-state) physics.

In 1968, the Department of Defense awarded the

money to Catholic University, and the Vitreous State Laboratory was born. "We were ecstatic," remembers Professor Montrose. "We celebrated in the way all scientists celebrate: with bad champagne in paper cups."
Using the $600,000, the professors were able to buy state-of-the-art scientific equipment and bring on post-doctoral fellows to help with multi-disciplinary research.

"With the wonderful equipment, we were able to make measurements that nobody else could, so our publications were very unique," says Professor Macedo. "The result is that VSL solved real scientific problems — such as defining for the first time how to transmit infrared light."

Major Contributions
Within 18 months, VSL's infrared research resulted in Texas Instruments' invention of infrared-transmitting glass, which allowed planes flying over Vietnam to "see" and count the Viet Cong on the ground by their body heat — even at night and hidden under thick tree cover. It was the first of a string of VSL-generated scientific advances.

The lab's understanding of infrared light made CUA the world's leading university in the development of fiberoptics, according to Ishwar Aggarwal, Ph.D. 1974, head of fiberoptics for the Naval Research Laboratory, based in Washington, D.C. Later perfected by Corning, fiberoptics — the use of strands of glass to transmit information via infrared light — has gone on to replace copper wire as the foundation for the world's telecommunications.

In the mid-1970s, professors Macedo and Litovitz learned about the military's concern about its new pilotless airplanes — now called cruise missiles.

The military's problem was that the prototype's fuel and lubricant didn't work. Using insights from glass science, Professor Macedo came up with a usable fuel and Professor Litovitz solved the lubricant issue — and the cruise missile became operational.

In addition, VSL developed an ion exchange process in which porous glass removes particular radioactive pollutants from water. The lab commercialized this and other technologies in a for-profit company called Duratek, which VSL incubated in 1977. Duratek, which is separate from VSL but often works in partnership with it, last year brought in $280 million in revenues.

As a result of the CUA lab's many technological advances, Professor Macedo became the Washington, D.C.-area resident who was granted the most patents — 28 — between 1979 and 1988, according to the Washington Business Journal. Four of the other top 12 Washington-area patent holders were also VSL staff members.

Although many of VSL's advances were developed by the laboratory's leaders, a large number of the discoveries came from the bottom up — from a battery of hard-working graduate students, technicians and post-doctoral fellows, says Professor Montrose.

"VSL has done a tremendous amount of good," Professor Macedo concludes, and the U.S. General Accounting Office has apparently shared that opinion. In the 1980s, GAO officials told VSL that the CUA lab had produced more products per government research dollar invested than any university, corporation or laboratory in the country. The lab's increasing stature was indicated by the

organizations that were becoming its major competitors. More and more, its competitors were not other university labs, but rather giant corporations and government laboratories enjoying funding levels many times higher than VSL's.

"I remember how Father [William] Byron [then the president of CUA] wrote to the chairman of Corning Glass in the late 1980s asking for research money," says Professor Litovitz. "He wrote, 'We have a great glass science program here. Could you contribute to Catholic U. to help it?' Corning replied: 'No, we can't contribute. We agree VSL is great. But they're our competitor.' "

This evidence that the world's leading glass company respected VSL as a competitor warmed the hearts of professors Litovitz, Macedo and Montrose.

Because of the tangible contributions that VSL had made to the United States and its military, Father Byron was able to successfully lobby Congress to fund the construction of CUA's Hannan Hall, finished in 1987. The high-tech facility houses both VSL and the physics department. On its ground floor is the Karl F. Herzfeld Auditorium, named in honor of the spiritual father of VSL and the physics department.

By the time of Hannan Hall's construction, VSL had turned away from military research and was committed to solving the nation's most pressing environmental problem: what to do with America's hundreds of millions of gallons of nuclear waste.

What's at Stake

Nobody gave much thought to the problem of what to do with radioactive waste during the rush to create the first atomic bomb and to produce tens of

thousands of nuclear warheads during the Cold War. The Hanford plutonium-processing plants stored their high-level radioactive waste in underground tanks designed to last only 25 to 30 years — some of which began leaking copiously as early as the late 1950s.

The bad news is that at least 67 of the 177 tanks have hemorrhaged nuclear waste that is flowing toward the Columbia River, a prime spawning bed for endangered salmon.

On the positive side, the leakage — estimated at between 1 million and 2 million gallons — has not yet flowed the seven miles to reach the Columbia River, although some of it has percolated the 200 vertical feet to reach ground water. Nobody knows how much of the waste will eventually reach the river.

Also on the positive side, the storage tanks are no longer leaking, as their liquid component has been piped to tanks that are still intact.
"But eventually all the tanks will fail and leak if we don't get the waste out of them," notes Douglas Huston of the Oregon Office of Energy's Nuclear Safety Division.

When and if the leaked waste reaches the river it will enter into the food chain that includes plants, insects, fish and cattle. This threatens people because living organisms such as fish concentrate radioactivity at a level 100,000 times higher than does the river water itself. Humans who eat radioactive fish and cattle inherit a highly concentrated dose of radioactivity, which can cause increased incidence of cancer, radiation sickness and genetic defects.

Moreover, major problems with the waste tanks could have a devastating effect on the economy of the Northwest, says the DOE's Mr. Boston. That's because the Columbia River is the lifeblood of Oregon and Washington — used for drinking water, recreation and irrigation. Tainted river water could make the area's products unpopular around the world. Or as Mr. Huston put it to this CUA Magazine writer, "Are you going to buy apples irrigated with water that is potentially radioactive?"

Cleaning Up

Glass lasts a long, long time. At the request of the Nuclear Regulatory Commission, VSL in the late 1970s did the basic science to prove that glass could last for the tens of thousands of years that nuclear waste can remain dangerous. The lab backed this up by pointing to historic and geologic precedents: glass created by the ancient Romans, which has lasted 2,000 years, volcanic glasses such as obsidian that have lasted millions of years and moon glass that has lasted a billion years, according to scientists.

Vitrification is now "the international standard for dealing with high-level radioactive wastes," says Mr. Boston, and VSL is an international leader in the science of vitrification. Representatives of foreign governments frequently pass through Hannan Hall, asking for advice on how to deal with their nuclear waste.

The lab's 17 years of leadership in vitrifying nuclear waste has led to the biggest challenge of all — Hanford — "the single most polluted place in the Western world," according to former Secretary of the Interior Udall.

The giant engineering firm, Bechtel, is overseeing the $4 billion construction of the vitrification

facilities at Hanford. Duratek — which employs VSL-developed technology — will design the vitrification facilities. VSL will consult in that design and then oversee the science of turning the waste into glass.

In particular, VSL will determine how much nuclear waste can be melted into the glass, formulate the glass-making recipe for each batch of waste, ensure that the whole process meets environmental standards, and make sure the glass that is being made is durable and doesn't destroy or clog the melters.

"On a problem as complex as Hanford, our success comes through providing indispensable expertise to our clients — and we get smarter in the process," says the English-born Professor Pegg, who, as the project's principal investigator, is at the center of VSL's Hanford work.
Professor Pegg won the Hanford contract through the 1995 proposal he penned, and he has increased VSL's involvement in the project while serving as the lab's primary contact with the Department of Energy and Bechtel sponsors.
"What Litovitz, Macedo and Montrose started won't get finished unless we have someone like Pegg," says James Mayo, CUA's associate provost of sponsored research.
"Ian is the future of VSL, whereas I'm likely to retire in about five years," says Professor Macedo. "Ian has multiplied the amount of money coming in to VSL from $2 million to $14 million per year through the wonderful job he does of writing proposals, interacting with clients and doing scientific research."

It's the People
VSL's most important product isn't nuclear waste

vitrification but education, according to professors Macedo and Montrose. The lab has trained many of the nation's leading glass scientists, who have gone on to become presidents, vice presidents and directors of research for companies in the United States, Japan, Canada, Brazil and Belgium — and heads of fiberoptics for the Air Force, Navy and NASA.

VSL's staff, which has increased from 40 to 100 employees in the past four years, has long been a virtual United Nations and now includes representatives from 20 countries.

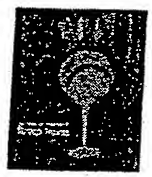
"When the Israelis invaded Lebanon in 1982, we had three Israelis, one Christian Lebanese, one Muslim Lebanese and one Syrian," says Professor Macedo. "When India and Pakistan fought in 1971 we had four Indians and three Pakistanis. But there were no fights at VSL."

For the future, Professor Macedo says he can foresee the possibility that VSL will need another building or two on campus. Even if that happens, though, the laboratory will probably maintain its low profile — a VSL value that Professor Litovitz illustrates through an amusing story.

In 1977 he and Professor Macedo went on ABC's "Good Morning America" to talk about the vitrification of nuclear waste. "I came back to Washington feeling puffed up," Professor Litovitz says, "and I went to see Herzfeld, who was bedridden. He asked, 'What's new, Dr. Litovitz?' and I told him about being on the TV show. I went on about the details such as the limousine that picked us up. When I was done, I looked at him and I have no doubt I expected a pat on the back. Instead he said to me, with his German accent,

'Professor Litovitz, could you do me a favor? Could you bring me a copy of the learned papers which you have written recently?'

"I was simply chastened. I understood what he was getting at. Who remembers our four minutes of fame on 'Good Morning America,' other than my wife? But hopefully our papers will make a contribution to society. Careful publication of research is something that other scientists can build on and something that will affect science for decades."



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Education

(1963) Ph.D. Physics, The Catholic University of America
(1959) B.S. George Washington University

Publications

Over 100 referenced publications.
Over 40 issued patents in the U.S.A., and many more worldwide.

Employment

1963 – 1967	National Bureau of Standards—continued afterwards as a consultant.
1967 – Pres.	**Co-Director, Vitreous State Laboratory; Ordinary Professor (1970),** Chemical Engineering and Material Sciences, currently Physics Department faculty, The Catholic University of America, Washington D.C. 20064

60's National Bureau of Standards recommended Dr. Macedo to an Academy of Science committee studying the technical problems with infrared transmitting glasses. He recognized that these problems were due to a lack in basic science. The proposal for the Themis Grant of DOD by The Catholic University of America was to form a center of excellence in Glass Science in order to address these problems. It was awarded and created the VSL in 1968. It resulted in Texas Instrument producing an infrared window within 18 months to look for the Vietcong from U2 spy planes.

70's VSL worked on fiber optics with the following results:

a) U.S. Air Force Office of Scientific Research notified Congress that VSL's Fiber Optics research was their leading research effort (at which time Dr. Macedo's first patent application was submitted to the A.F.O.S.R.)
b) The Fiber Optics patents were licensed to the following companies: Noranda, Pilkington, Sumitomo, American Cystoscope Makers, Biomedics International and Abbot.
c) VSL worked for DARPA (DOD) on the development of the Cruise Missile. We significantly advanced the basic science of Lubrication leading to a new product by Monsanto, as well as very high energy fuels leading to a product produced by Shell.

80's US GAO review found that VSL had the best record of technology transferred per R& D dollar invested, Some of VSL's best technologies for the decade are given below:

a) Patent on selective ion exchange which lead to the IPO of Duratek, Inc. (formerly GTS Duratek, Inc.).
b) Patent on Foam Glass which led to IPO of Energy Solutions.
c) Work on basic science of nuclear waste leaching resulted in Dr. Macedo being chairman of ASTM committee which provided the framework for permitting the fabrication of high level nuclear waste glass at Savannah River and West Valley.
d) Formulation of the high level nuclear waste glass permitted the cleanup of West Valley at a cost of $1.5 Billion. This work included cooperation with the following companies: Westinghouse, DuPont, and Battelle.
e) Dr. P.B. Macedo is noted as *"the area's leading individual inventor in number of patents granted in the last 10 years"* (Washington Business Journal Magazine.

90's Dr Macedo's most successful patent, *"The use of bubblers to stir and thereby increase throughput of Joule Heated Melters"*, resulted in:

a) The U.S. DOE notified Congress that the GTS Duratek/VSL team performed the most successful research that year.
b) GTS Duratek was awarded a privatization contract to vitrify ~ 1,000 tons of glass in M-Area of the DOE Savannah River Plant.
c) Permitted GTS Duratek to go public for a second time and obtain sufficient funds to increase annual sales from the mid $20M to the mid $200M.
d) GTS Duratek formed a partnership with BNFL that won the privatization contracts both part A and part B for the Hanford site tank cleanup project.
e) Additional companies which VSL cooperated in development and technology transfer during the 90's: Lockheed, Martin Marietta, Molten Metal, EG&G, B&W, Morrison &Knudsen, and Mason Hanger.

2000's The inventions of the 90's continue to work: Dr. Harry Boston, former manager of the DOE's Office of River Protection (which is the leading waste tank cleanup project at the Hanford site), stated *"VSL/CUA's unique expertise will contribute to making the cleanup 20 years faster and up to $20 billion cheaper."*

a) Based on Duratek's design and VSL's research, Bechtel is building the vitrification plant for High Level Nuclear Waste for about $5B at the Hanford site, called "*...the most contaminated site in the western world*".
b) Dr. Macedo has started a new line of research by writing three new patent applications in foam glass-**Silica Web**™ –*"The More Responsible Alternative in Building Products"*™

Recent Patents

Hojaji, Hamid et al., Large high density foam glass tile composite, U.S. Publ. No. 2003-0145534, published August 7, 2004 and U.S. Publ. No. 2004-0123535, published July 1, 2004.

Buarque de Macedo, Pedro M. et al., Chalcogenide ceramics for the disposal of radioactive and/or hazardous waste, U.S. Publ. No. 2004-0111003 A1, published June 10, 2004.

Hojaji, Hamid et al., Strong, High Density Foam Glass Tile, pending U.S. Patent Application filed 2003.

Buarque de Macedo, Pedro M., Prestressed Foam Glass Tiles, pending U.S. Patent Application, filed 2003.

Buarque de Macedo, Pedro M. et al., Method and Apparatus of Removing Antimony, pending U.S. Patent Application, filed 2004.